



# PCIe® Form Factor Review

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# PCI-SIG Mechanical Ecosystem

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## PCI-SIG Mechanical Ecosystem

CEM

CEM 2x4 High-power  
Cable (+225W)

M.2

OCuLink

External Cable

SFF-8639

- **PCI-SIG specifies a suite of PCIe<sup>®</sup> mechanical form factors**
  - Applicable across multiple market segments
  - Enable platforms and devices to be tailored to meet solution-specific needs



# PCIe CEM



- **Applicable market segments**

- Towers (client / server), Data Center (server, storage, I/O)

- **Supported Component Types**

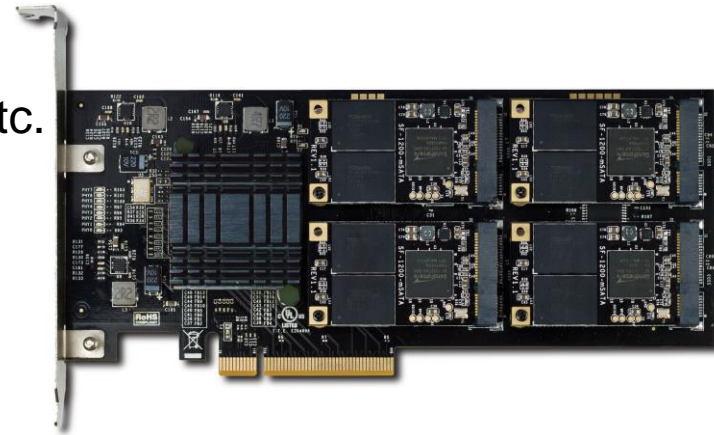
- NIC, GPU, GPGPU, FPGA, DSP, ASIC, SSD, etc.

- **Supported Connectors**

- CEM x1, x4, x8, x16 up to 32 GT/s
- 2x3 and 2x4 High Power Cables

- **CEM Benefits:**

- CEM baseline, i.e., reference for multiple mechanical form factors throughout industry
- Forward / backward compatibility—1.0-5.0 provides consistent customer experience
- Four sizes to tailor I/O to meet solution-specific needs
- Scalable power—up to 75W (edge), 2x4 enables 300W (CEM 4.0) / 600W (CEM 5.0)
- Supports hybrid computing (processor + accelerators)
- Supports external cables (PCIe, DP / HDMI, Ethernet, IB, FC, SAS / SATA, etc.)



# PCIe M.2



- **Applicable market segments**
  - Embedded / T&M, Client, Data center (e.g., SSD carrier)
    - Connector and BGA solutions
- **Supported Component Types**
  - 15 form factors capable of supporting many applications including: Wi-Fi, Bluetooth, NFC, 2G-4G, Hybrid Radio, SSD, etc.
- **Supported Connectors**
  - x1 / x2 / x4: Mid-mount, single-sided, double-sided
- **M.2 Benefits:**
  - Large, flexible mechanical form factor family
  - Supports multiple protocols: PCIe, SATA, USB, etc.
  - Supports 14 vendor-defined pins to customize solutions
  - Forward / backward compatibility
  - Low power (3.3V & 1.8V using 4 power pins)
  - Supports external connectivity: cables, antennae, etc.
  - Multiple M.2 can be provisioned on a carrier form factor

Example M.2 SSD



Example M.2 Carriers

# PCIe Cables

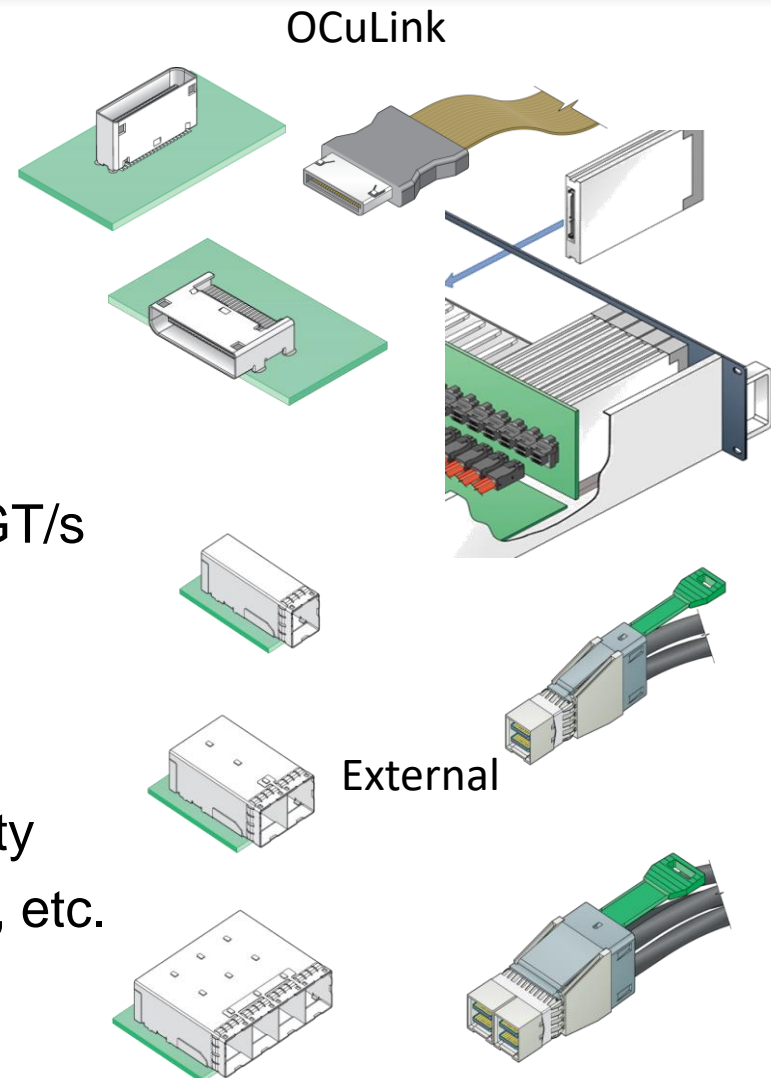


- **OCuLink—Internal / external cable**

- Single x4 connector up to 16 GT/s
- Passive CU & active CU | optical
- Supports coax and ribbon cables
- Key application: NVMe / SAS SSD

- **External Cabling**

- x1, x4, x8, and x16 connector up to 8 GT/s
- Passive CU & active CU | optical
- Supports coax cables
- Key applications:
  - I/O expansion enclosure connectivity
  - PXI / AXIe-based T&M, automation, etc.



# SFF-8639 (AKA U.2)—SSD



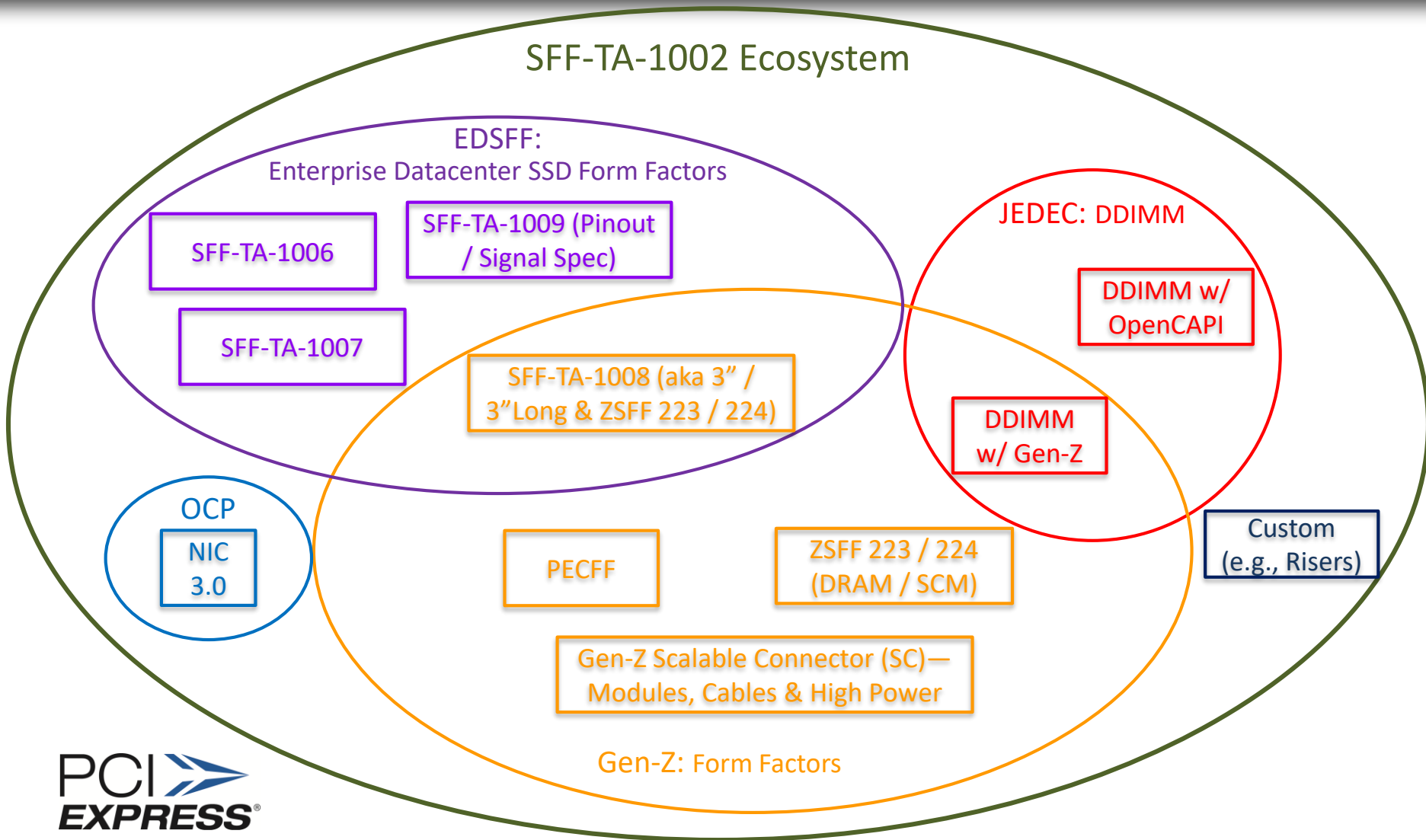
- **Applicable market segments**
  - Primarily data center with some enthusiast desktop
- **Size: 15 x 70 x 100.45 mm up to 25W**
- **Supported Connector**
  - SFF-8639 (PCIe 1 x4 or 2 x2)
- **SFF-8639 / U.2 Benefits:**
  - Adds PCIe support to high-volume 2.5" HDD form factor
  - Supports PCIe up to 16 GT/s
  - High-capacity / high-density NVM form factor
    - Up to 24 modules in 2U enclosure
    - Up to 32 14x18 mm packages per module
  - Case for ESD protection and hot-plug support
- **U.3 builds upon U.2 to ease SATA-to-NVMe Transition**
  - Tri-mode enables PCIe to share SAS/SATA pins, which reduces infrastructure costs for Low Power Value NVMe
  - Universal Bay HW RAID uses fewer ROC ports
  - Prevents stranded lanes





# Other PCI Express Mechanical Ecosystems

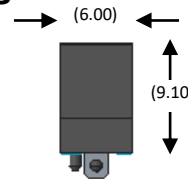
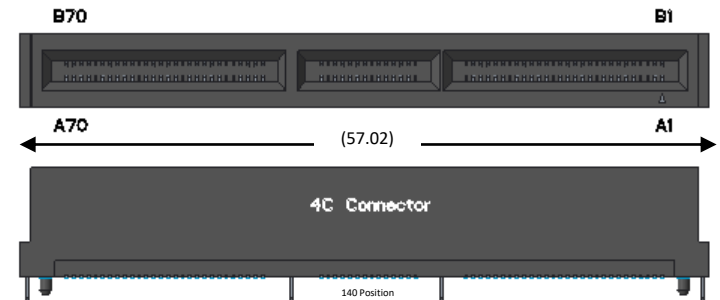
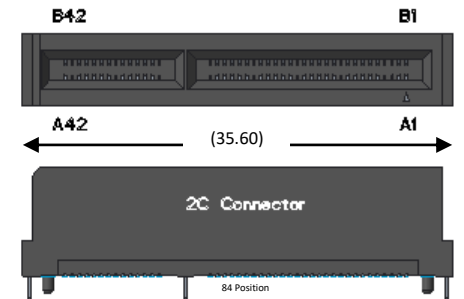
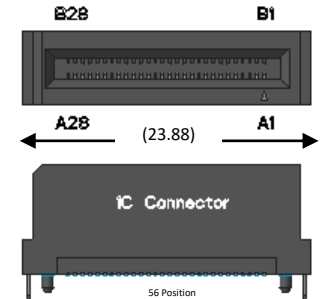
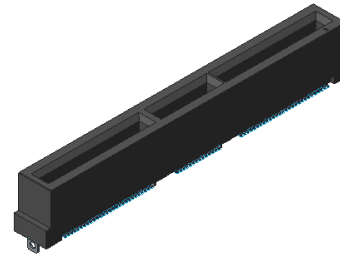
# SFF-TA-1002 Mechanical Ecosystem



# SFF-TA-1002



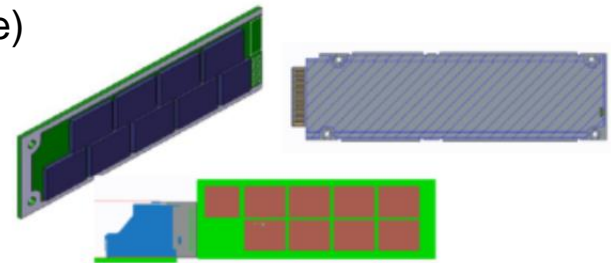
- **SFF-TA-1002 covers mechanical and electrical**
  - Form factors specify pinouts
- **Connector variations: 1C, 2C, 4C, 4C+**
  - Full mechanical interoperability
    - Small-in-large, large-in-small
    - OCP NIC 3.0 supports 4C+
  - Vertical, right angle, and straddle mount connectors
  - Up to 80W @ 12V through power pins in 1C section
    - 3.3Vaux
  - Supports multiple physical layers—PCIe, 802.3 electrical, etc.
    - SMT connectors supports 2.5 GT/s NRZ to 112 GT/s PAM-4
    - Press-fit orthogonal-only connectors supports 2.5 GT/s NRZ to 16 GT/s NRZ
  - Supports multiple links per connector
  - Supports multiple interconnect technologies: PCIe, Gen-Z,
  - Smaller connector improves density, SI, PCA yield, etc.
    - Used with SSD, smaller connector improves airflow
- **Gen-Z SC includes 4C-HP & Cable capabilities**
  - 4C-HP up to 660W @ 12V, 1024W @ 48V
  - Supports coax and ribbon cables
    - Supports passive & active CU | photonics



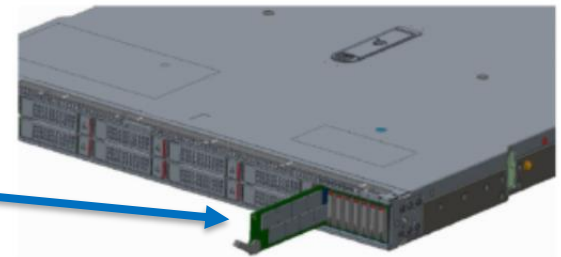
# SFF-TA-1006—SSD



- **Applicable market segments**
  - Data Center (1U optimized server and storage enclosure)
- **Size**
  - 5.75 / 7.55 x 31.5 x 111.5 mm supports up to 12W
- **Supports SFF-TA-1002 1C (PCIe x4)**
- **SFF-TA-1006 Benefits:**
  - PCIe to 32 GT/s
  - High-capacity / high-density NVM form factor
    - Up to 36 modules
    - Up to 12 14x18 mm packages per module
      - 432 packages / U
  - Case & Case-less Options



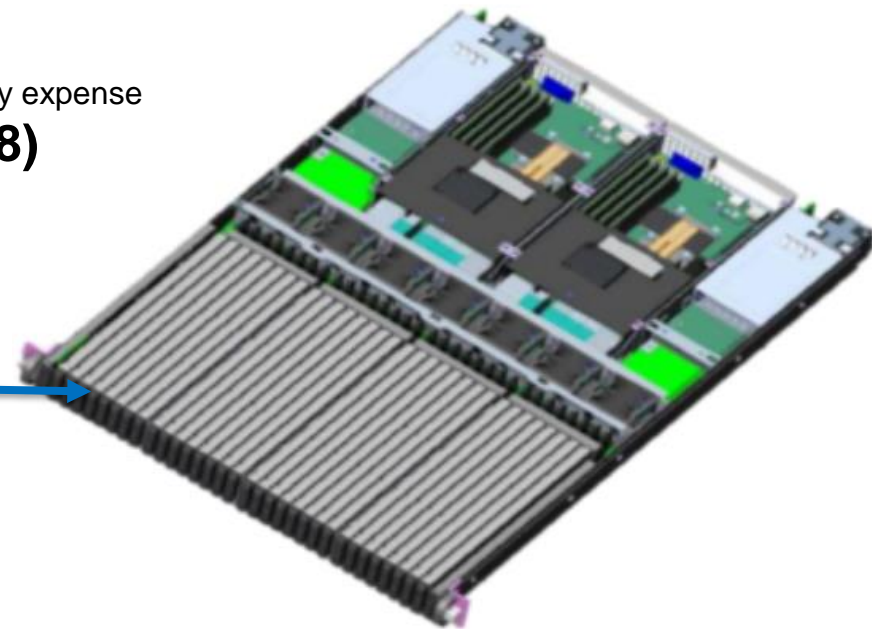
Drive Mated in RA Orthogonal Connector



# SFF-TA-1007—SSD



- **Applicable market segments**
  - Data Center (1U optimized server and storage enclosure)
- **Sizes**
  - 9.5 x 38.4 x 318.75 mm supports up to 25W
  - 18 x 38.4 x 318.75 mm supports up to 40W
    - Adds heat sink to improve cooling at system density expense
- **Supports SFF-TA-1002 2C (PCIe x4-x8)**
- **SFF-TA-1007 Benefits:**
  - PCIe to 32 GT/s
  - High-capacity / high-density NVM form factor
    - 9.5 mm
      - Up to 32 modules
      - Up to 44 14x18 mm packages per module
        - 1408 packages / U
    - 18 mm
      - Up to 18 modules
      - Up to 44 14x18 mm packages per module
        - 704 packages / U
  - Supports data-centric computation
    - Reduce packages to free up space for integrated accelerator
  - Case for ESD protection, thermal management, & hot-plug



# SFF-TA-1008—SSD

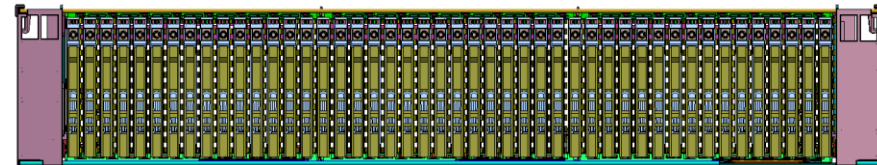


- **Applicable market segments**

- Data Center (1U and 2U optimized server and storage enclosure)

- **Sizes**

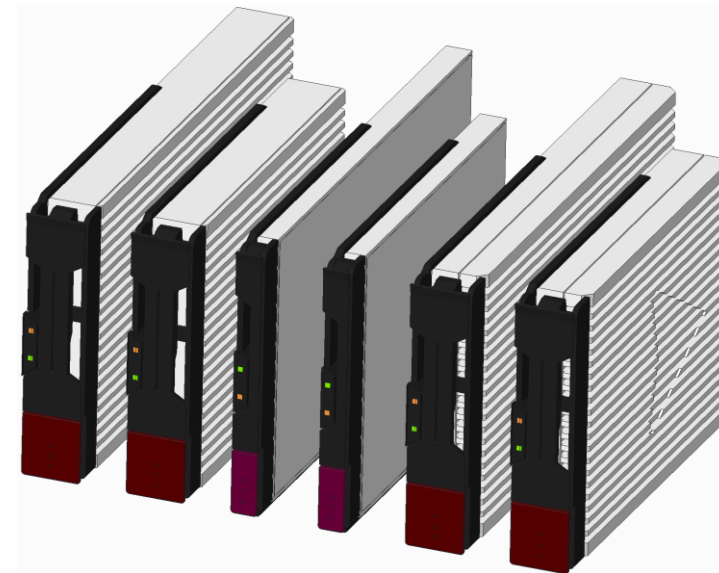
- 7.5 x 76 x 104.9 mm supports up to 25W
- 7.5 x 76 x 142.2 mm supports up to 35W
- 16.8 x 76 x 104.9 mm supports up to 70W
- 16.8 x 76 x 142.2 mm supports up to 70W



- **Supports SFF-TA-1002 1C, 2C, 4C (PCIe x4-x16)**

- **SFF-TA-1008 Benefits:**

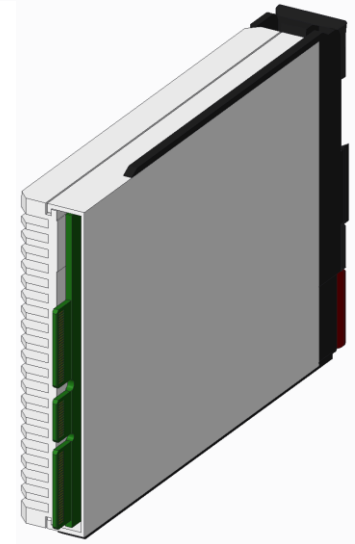
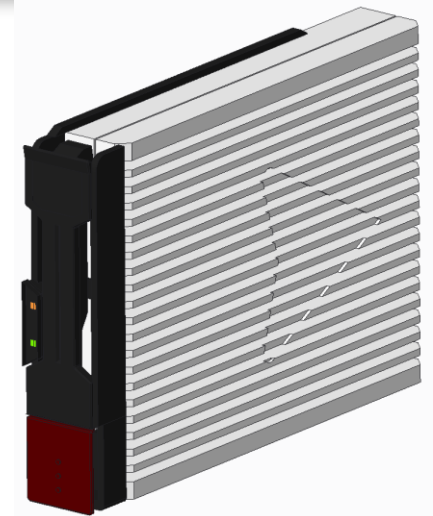
- PCIe to 32 GT/s, 802.3 to 112 GT/s
- High-capacity / high-density NVM form factor
  - 7.5 mm
    - Up to 48 modules
    - 104.9 up to 24 14x18 mm packages per module (576 / U)
    - 142.2 up to 48 14x18 mm packages per module (960 / U)
  - 16.8 mm
    - Up to 24 modules
    - Up to 48 14x18 mm flash packages per module (960 / U)
- Supports data-centric computation
  - Reduce packages to free up space for integrated accelerator
- Case for ESD protection and hot-plug support
- Aligns with ZSFF 223 and ZSFF 224



# ZSFF 223 / 224—DRAM & SCM

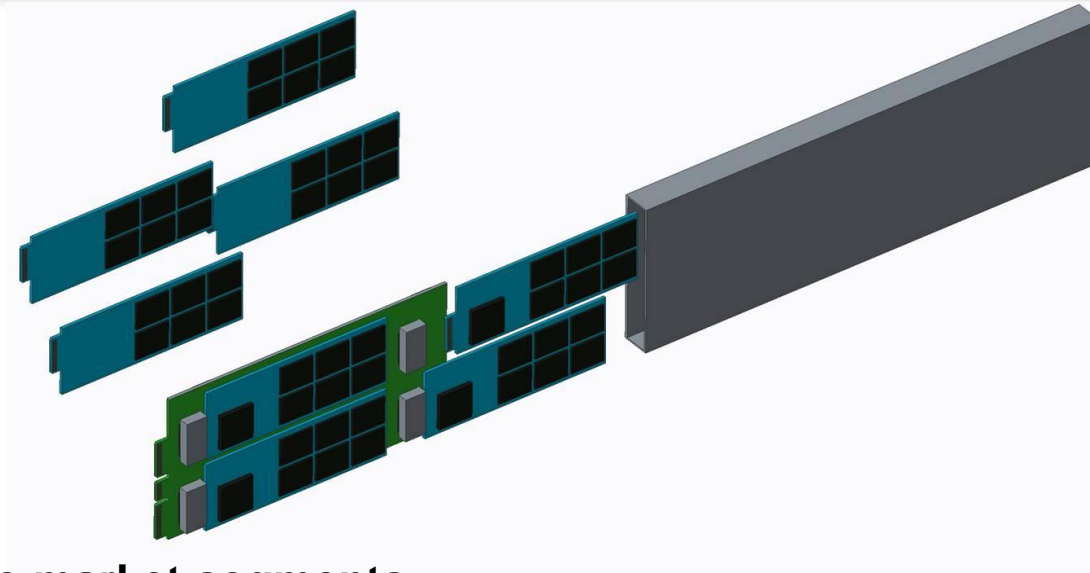


- **Applicable market segments**
  - Data Center (1U and 2U optimized server and storage enclosure)
- **Sizes (SFF-TA-1008 Variation)**
  - 16.8 x 76 x 104.9 mm supports up to 70W
  - 16.8 x 76 x 142.2 mm supports up to 70W
- **Supports SFF-TA-1002 1C, 2C, 4C (PCIe x4-x16)**
- **ZSFF 223 / 224 Benefits:**
  - PCIe PHY to 32 GT/s, 802.3 to 112 GT/s
  - High-capacity / high-density DRAM and SCM form factor
    - Up to 24 modules
    - Up to 280 GiB DDR5 DRAM Media (256 GiB Data + ECC)
    - Up to 5 TiB SCM Media
  - Supports data-centric computation
    - Reduce packages to free up space for integrated accelerator
  - Case for ESD protection and hot-plug support
  - Front-to-back or side-to-side air flow grill options





# ZSFF 113



- **Applicable market segments**
  - Data Center (1U and 2U optimized server and storage enclosure)
- **Size**
  - 7.5 x 37 x 104.9 mm supports up to 25W
- **Supports SFF-TA-1002 1C, 2C (PCIe x4-x8)**
- **ZSFF 113 Benefits:**
  - PCIe to 32 GT/s, 802.3 to 112 GT/s
  - High-capacity / high-density NVM form factor—12 14x18 mm flash packages per module

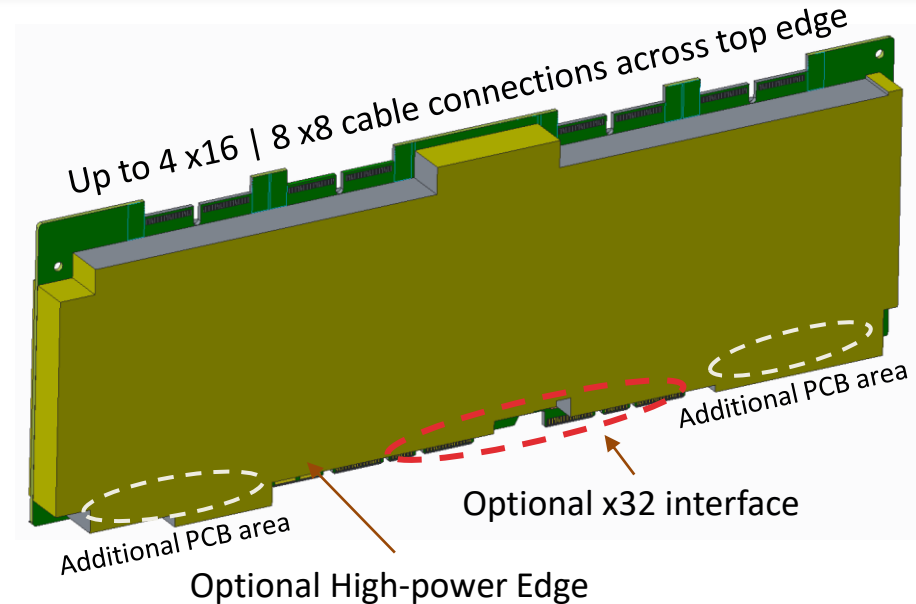




# PECFF (PCI Enclosure Compatible FF)



- **Applicable market segments**
  - Desktop, Data Center
- **Sizes: 4 PCIe CEM Sizes**
- **Supported Connectors:**
  - SFF-TA-1002 1C-4C
  - Gen-Z SC 4C-HP
- **PECFF Benefits:**
  - PCIe to 32 GT/s, 802.3 to 112 GT/s
  - 1C-4C: 80W card edge
  - 4C-HP: 12V to 660W, 48V to 1024W
    - Improves power / thermal
    - 48V improves power efficiency
  - Shifts card edge 60 mm closer to processor
    - Recovers 4-8 dB motherboard loss budget
    - Recovers AIC loss budget / improves trace & device layout
    - Reduces system cost—retimers, \$\$ FR4, etc.
  - Supports optional 2<sup>nd</sup> 4C to provide x32
  - Supports optional top-edge cable connectors
    - Board space may be used for other purposes if cable area is not required



Example top edge cable connectivity



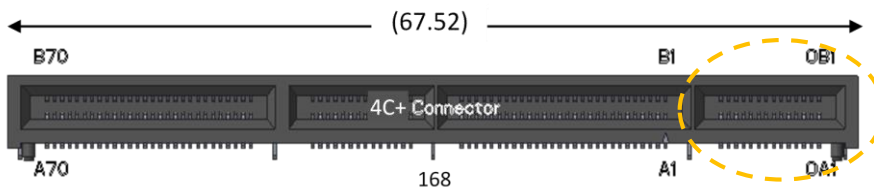
# OCP NIC 3.0



- **Applicable market segments**
  - Data Center (server)
- **Supports SFF-TA-1002 4C+**
  - Right angle and straddle mount
  - 4C+ contains additional sideband signal to support multiple servers to share I/O by splitting the connector into 4 links
- **Benefits:**
  - PCIe to 32 GT/s, 802.3 electrical to 112 GT/s
  - Enables servers to share mechanical infrastructure



x16 OCP NIC 3.0 (4C+)



28-pin section added for OCP sidebands



x8 OCP NIC 3.0 (4C+)

# Mechanical Design Considerations

performance  
HotSwap  
Serviceable  
PlatformOptimized  
ScalableCost  
LaneCount  
DualPort  
FaultDomain  
Robust  
Capacity  
PowerThermals  
Density  
Longevity  
MediaOptimized  
HighVolume  
StrandedLanes

- **PCI-SIG Continual Mechanical Development**
  - Range of mechanicals applicable across multiple markets
  - Full forward and backward compatibility from 1.0 to 5.0
  - PCIe CEM is the industry reference mechanical form factor
- **Diverse, vibrant mechanical ecosystem**
  - Multiple orgs accelerating / broadening PCIe adoption
    - SFF, OCP, Gen-Z, SD Card, PICMG, AXIe, etc.
    - Enables PCIe to be deployed across many more markets

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